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(NASA-NP-142) A DECADE ON BOARD AMERICA'S SPACE SHUTTLE (NASA) 20 p CSCL 22B

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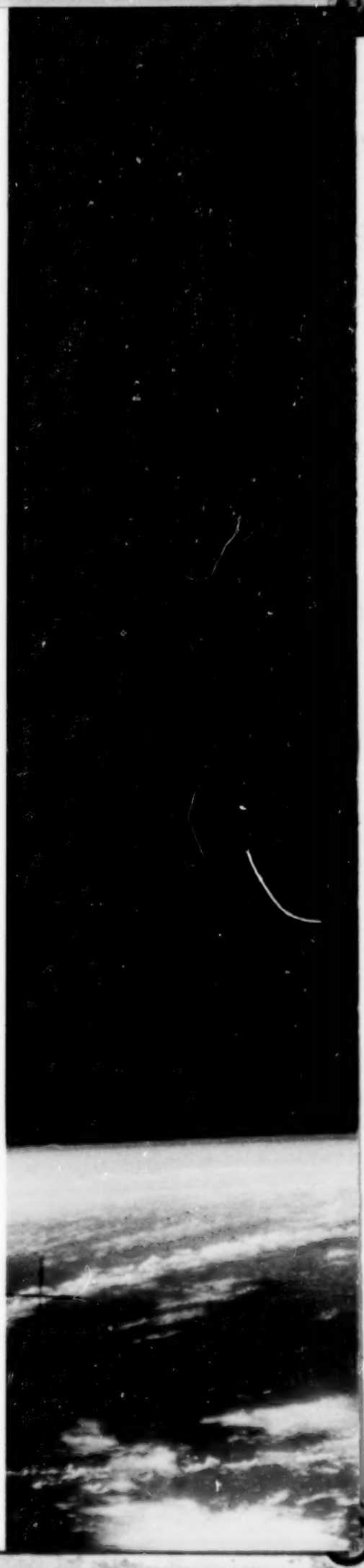
NASA

A Decade On Board America's Space Shuttle

10

Spectacular Moments From A Decade Of Shuttle Missions— Captured On Film By The Astronauts Who Flew Them.



The shuttle orbiter Challenger, photographed against the blackness of space by the Shuttle Pallet Satellite (SPAS-01), on June 22, 1983 during mission STS-7.

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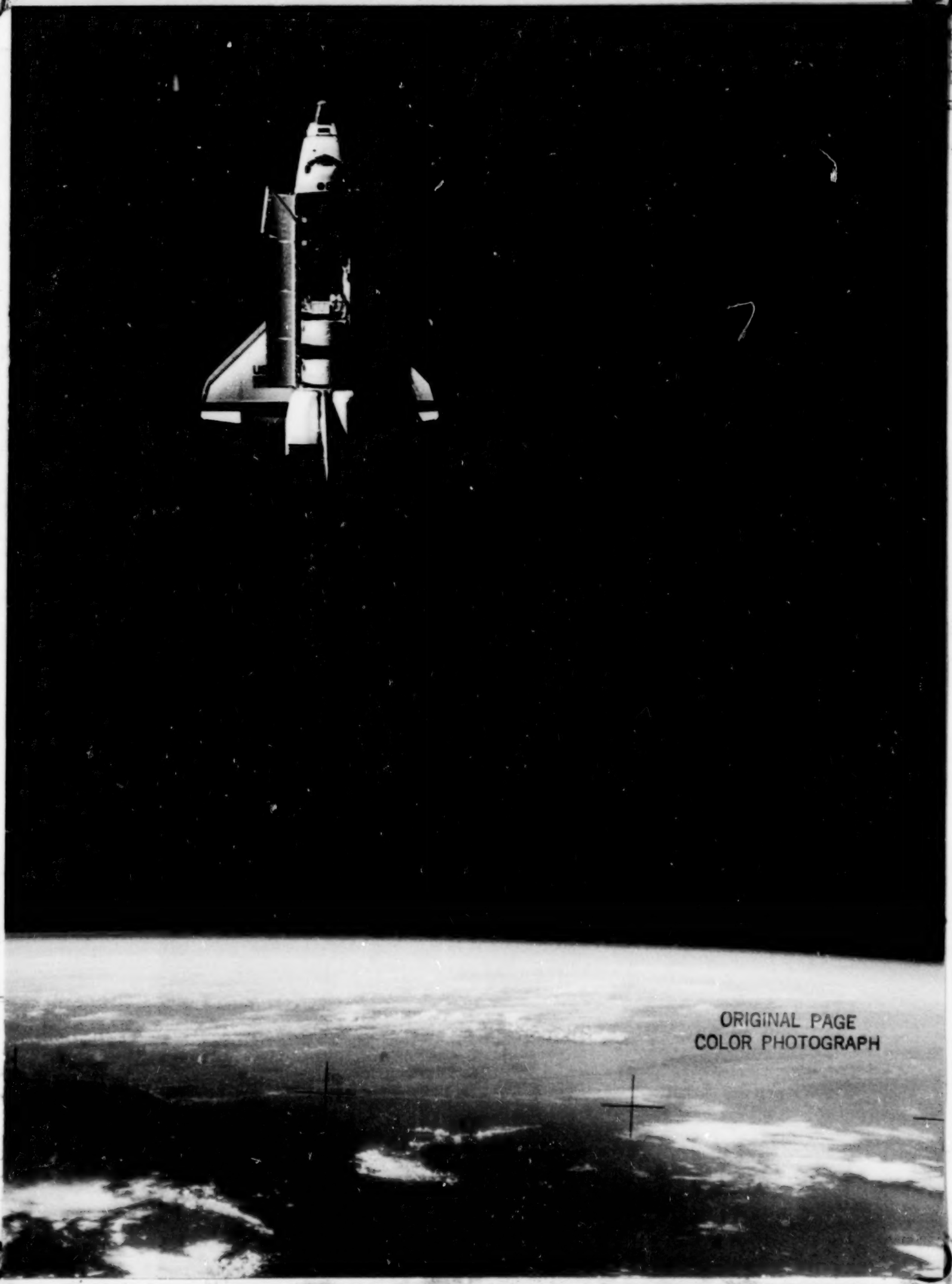

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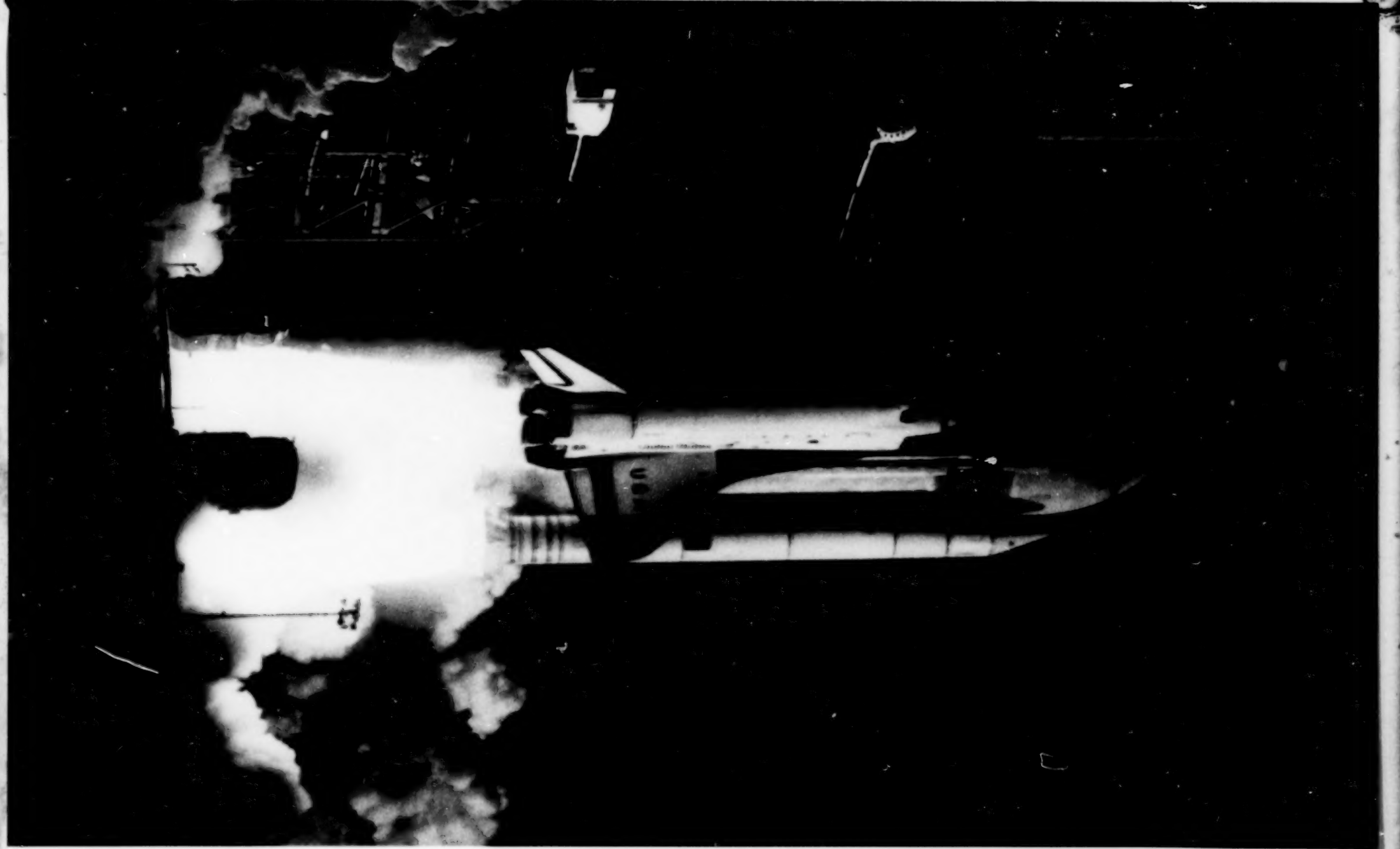

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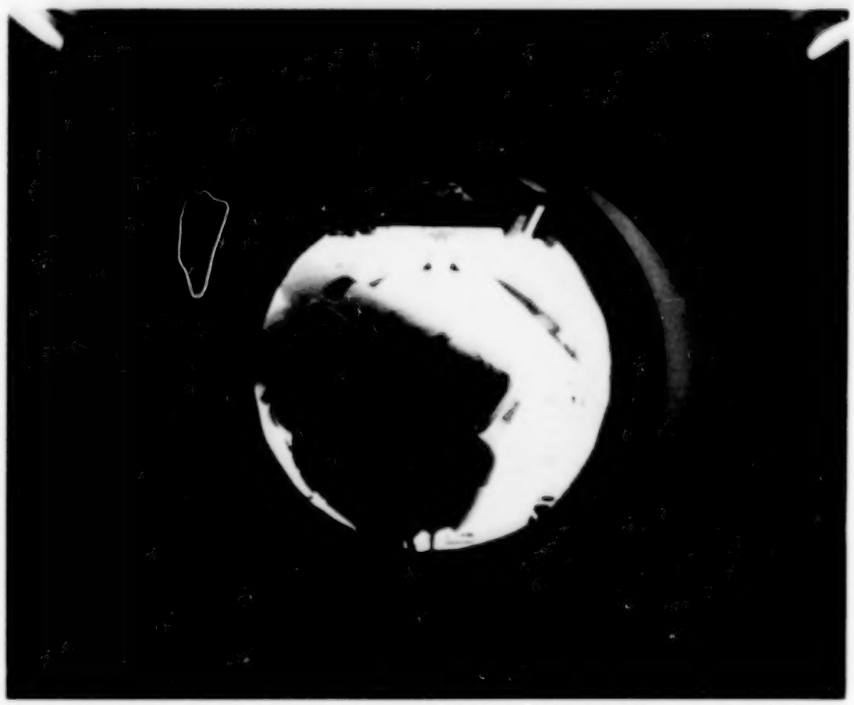
It's part airplane and part rocket, part satellite launcher, part bunkhouse, part laboratory and part locker room. Every so often, for a few days at a time—longer if the crew is lucky—it circles the Earth, a busy island of life in the still darkness of space. For a whole generation of astronauts, it's the only space vehicle they've ever known.

The world's first flying spaceship debuted on April 12, 1981—ending, probably forever, the era of space capsules and ocean splashdowns. Paul Weitz, a veteran from those old days, recalls glancing out the window during his 1983 Challenger flight: "You look back, and you're in orbit, and the damn thing has a wing and a tail....It's more Star Wars than Star Wars."

The shuttle has known glory and frustration, victory and loss. It's not the best spacecraft we'll ever have, but it's probably the best that's ever been. It brought a new versatility and diversity to space travel: Women, minorities and non-NASA scientists finally got their chance to fly, and in increasingly greater numbers— first two, then four, then seven at a time.

In 10 years the shuttle has ferried 204 people into orbit, along with monkeys, fruitflies, rats and bees. More than 40 satellites have been spun, craned and sprung from the cargo bay. Astronauts have wrestled seven-ton satellites by hand while skimming the Earth at 17,500 miles per hour. They've floated free in chairlike magic carpets. And they've seen things none of the rest of us ever get to see.

For our salute to the shuttle's tenth anniversary, we asked a dozen shuttle astronauts, past and present, to pick their own favorite shots from the last decade. Some of the photos they chose are dramatic, some have stories behind them, some are just plain pretty. Not surprisingly, all 12 astronauts included shots of the Earth on their list of favorites—proving once again that for all the wonders of the shuttle, it's the blue planet out the window that really stirs the soul. Just ask anyone who's been there.



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Shannon Lucid

"Everybody who goes over Australia takes this picture because it's so dramatic and has lots of colors in it. It was one picture that came out pretty close to what I actually remembered it looking like. But when I came back, and looked at all the pictures we took, none of them lived up to real life. It was almost to the point that you really didn't want to look at the pictures, because they would destroy what you actually remembered. They weren't as vivid."

Shark Bay, Australia. Mission STS-51-G, 1985.

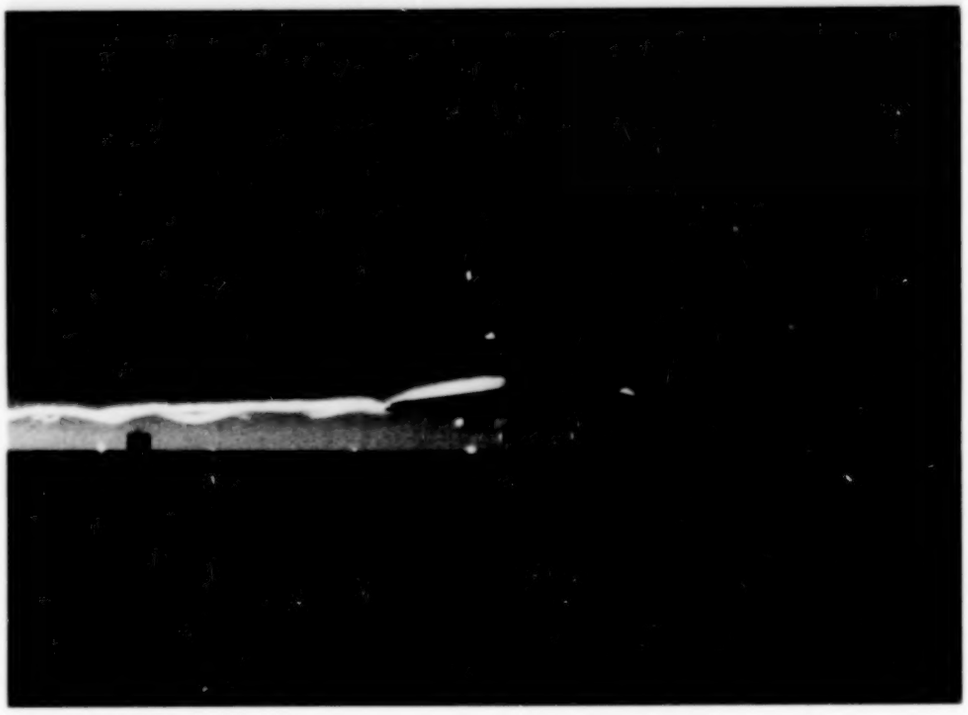
Marsha Ivins

"Before I became an astronaut I had been a flight engineer [flying landing simulations] on the Shuttle Training Aircraft. In that airplane I'd seen this picture about 15,000 times. I'd seen it at night, at Edwards, on that runway, probably 400 or 500 times. But this was the first time in the orbiter. And the thought did in fact cross my mind: 'This is not a simulation.'

And that thought kind of left a trail across my mind. I got little goose bumps on my neck. We rolled out on final, and we saw the lights of Los Angeles, and I thought, 'I've seen this picture before.' Then something in me said, 'Not *this* way you haven't.'

After 11 days, that was the moment I realized what I had been doing. It took me all 11 days to get there. [In space] I had been waiting for it to dawn on me what I was doing, and it didn't. I didn't make any major emotional leap until we rolled out on final, and I was looking out the window at night lights that I'd seen hundreds of times before on the STA, and I realized: *This is no drill*."

Night landing of Columbia at Edwards Air Force Base, California. Mission STS-32, 1990.



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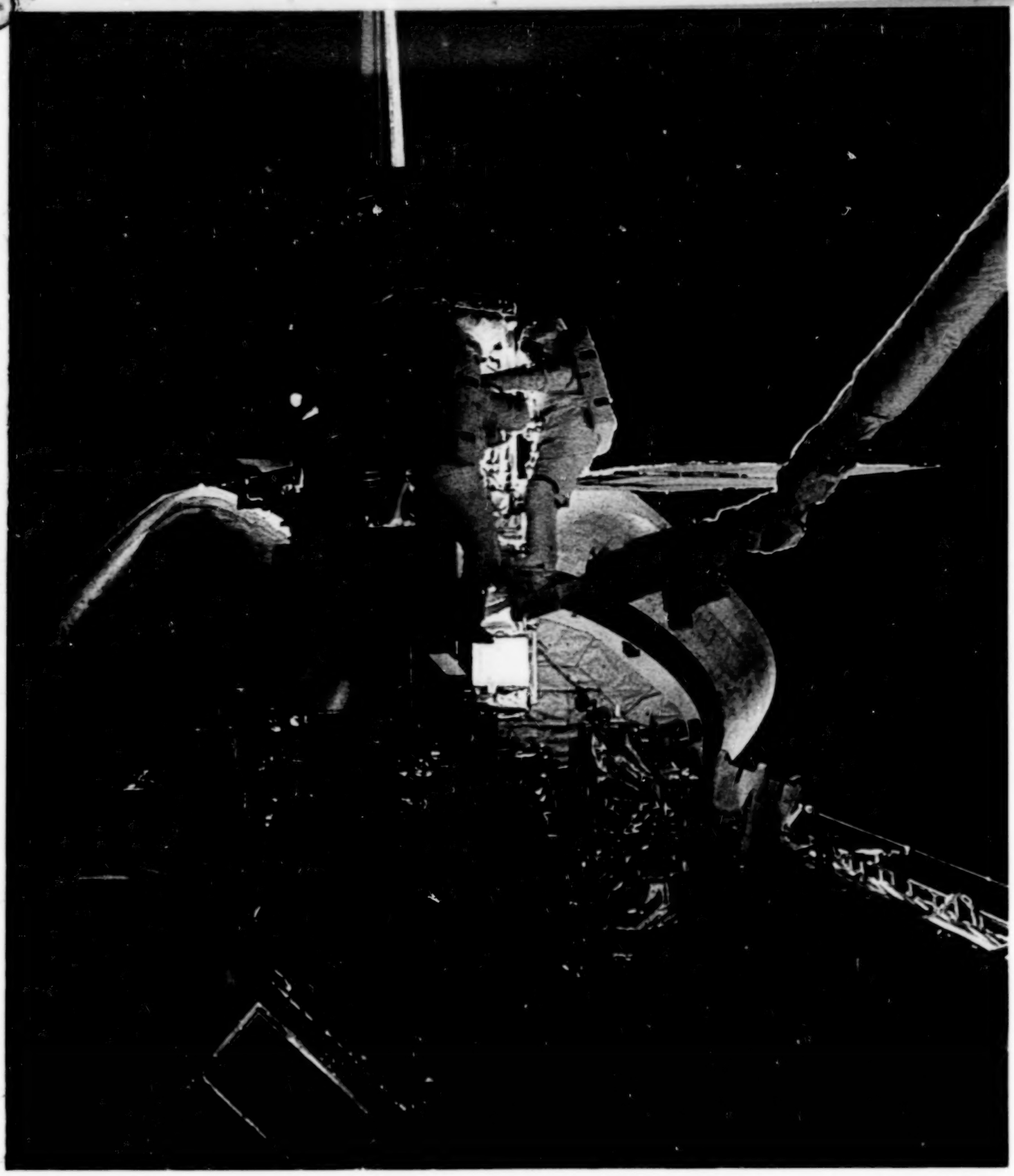

After retrieving the Solar Max satellite, James van Hoften (left) and Pinky Nelson repair it in orbit. Mission 41-C, 1984.

George "Pinky" Nelson

"Probably the most pleasant part of the whole mission was the time we spent out working on the satellite. We just had a ball, both of us. It was easy—we had trained just as hard for that as for the rendezvous. We'd done [the repair] who knows how many times already as we developed the procedures in the water tank. We'd done it every which way, at every which place. We had the whole repair down to a choreographed ballet, almost. We didn't have to communicate verbally all that much—I just knew where Ox was, and he knew where I was. It was fun. A spectacular view, things went well, and it was low stress. We really enjoyed it."

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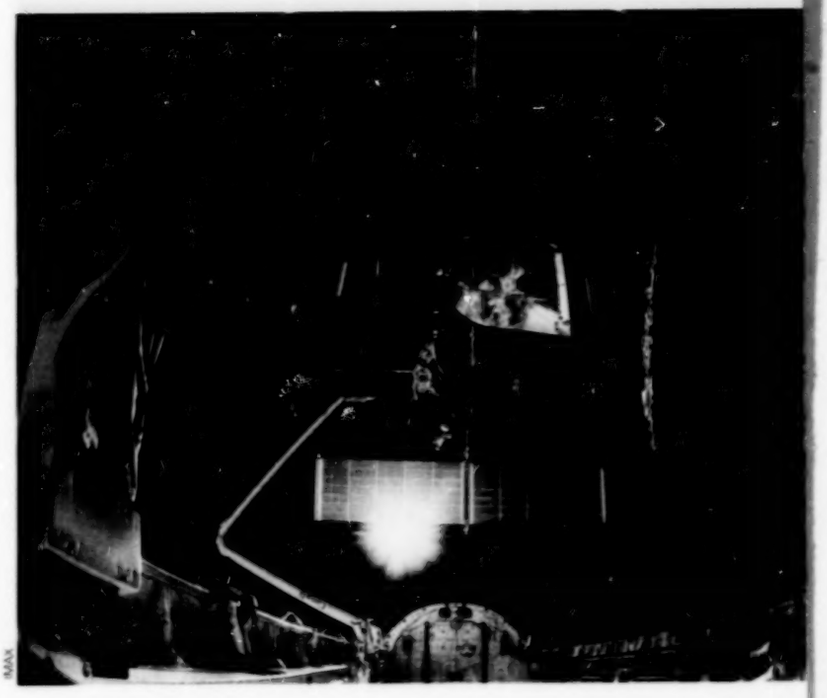
Steve Hawley

"Of all the photos of the Hubble Space Telescope I've seen, this is the one that's most memorable to me. It was the only shot of the release that was taken. We didn't get any stills, because Bruce and Kathy were locked up in the airlock, and they were the onboard photographers. It's a nice picture, but we had to cannibalize the IMAX movie to get it, because our own photographers were busy....

A lot of people who knew I was going to do the deploy were excited that it was going to be an astronomer who would do it. I always thought that was sort of irrelevant. What we really wanted was a good arm operator, not necessarily a good astronomer....

For the first several hours [after the deploy] I was interested in watching the telescope through binoculars just to see how far away I could make out details. I remember being able to convince myself I could see the solar arrays as distinct from the tube at a distance of 12 miles through binoculars. Once it got out to 40 miles, you knew it was the telescope—it was the brightest object there except for the Sun and the Moon—but you couldn't make out details."

Release of the Hubble Space Telescope as seen by an IMAX camera in Discovery's cargo bay. Mission STS-31, 1990.



IMAX

Woody Spring

"On that entire mission, from launch to landing, there was only twice when I had any real anxiety, and one of them was the first time I got on the end of that arm. There you are, 200 miles high, going 17,000 miles an hour. Those are all 'gee-whiz' numbers that don't mean anything when you're oriented to the shuttle. Then you step onto the arm from the sill of the payload bay, release your tether, and tie another little tether to your ankle.

The first job I had to do was to go to the top of this 45-foot structure. And I said, 'Mary, go ahead and take me up.' Well, she'd already been working with Jerry, so she was used to going full speed. She knew she had 45 feet to go, and she put the thing up to the max—0.7 feet per second. That's a pretty good clip.

So there I am, with no handhold in front of me, being held on by my ankles, watching everything that was safe and secure—my entire reference frame—moving away from me very, very fast. I just reached around behind me, grabbed hold and held on tight. The momentary panic only lasted about ten feet or so, but the first sensation was *Oh, my God.*"

Woody Spring maneuvers the 45-foot ACCESS structure while testing construction methods in space. Mission 61-B, 1985.

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James "Ox" van Hoften

"This is me on the end of the RMS, ready to try and grab onto LEASAT manually, wondering what in the hell I was doing out there. This was more hair-raising than releasing it into space [later in the mission]. The shuttle was very active, with 44 reaction control jets shooting out fireballs every which way, and I'm standing on the end of a 50-foot diving board, getting moved around, while approaching a 15,000-pound satellite, then trying to get hold of it with my hands. It was very *colorful*.

The problem was, the remote manipulator was disabled so it could only move in 'singles' mode—one joint at a time. Mike Lounge was trying to drive me around on the manipulator, and it was a real challenge. Trying to hold onto this thing and lower it down into the payload bay would have been a lot easier if the arm had been working right."

Bringing the LEASAT satellite into Discovery's cargo bay for repair. Mission 51-I, 1985.

Don Peterson

"Karol Bobko and I were talking as we were watching the sun set. The atmosphere, when you see it from this vantage point, looks very small, like a shell of air around the Earth. And the thought hit both of us that when you looked out in the other direction, away from the Earth, you couldn't see anything as far as you looked. The only light we could see was that little strip of colors. We started out saying how pretty and colorful it was to watch. Then we said 'Boy, that kind of makes you feel lonesome out here.' By the time we finished the conversation, the sunset was gone."

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Sunset from onboard Challenger. Mission STS-6, 1983.

Kathy Sullivan and Loren Shriver on the flight deck of Discovery. Mission STS-31, 1990.

Charles Bolden

"Usually you try to sneak up on somebody and take a photo that shows a genuine view of what it's really like, and I think this one was successful....I was up on the flight deck, curled up on the left-hand aft panel, shooting into the cabin. We were trying to get set up to start our Earth observations....

As a general rule, people like to be up on the flight deck as much as possible, so there are times when everybody's up there. And then you just kind of jockey for position to see who can get the best window....

On both my flights, I've slept on the flight deck, just because I prefer it. I usually just float over my seat. In the photo, you can see that my seat [near the window] and Steve Hawley's seat in back are folded down, to make them like a table."

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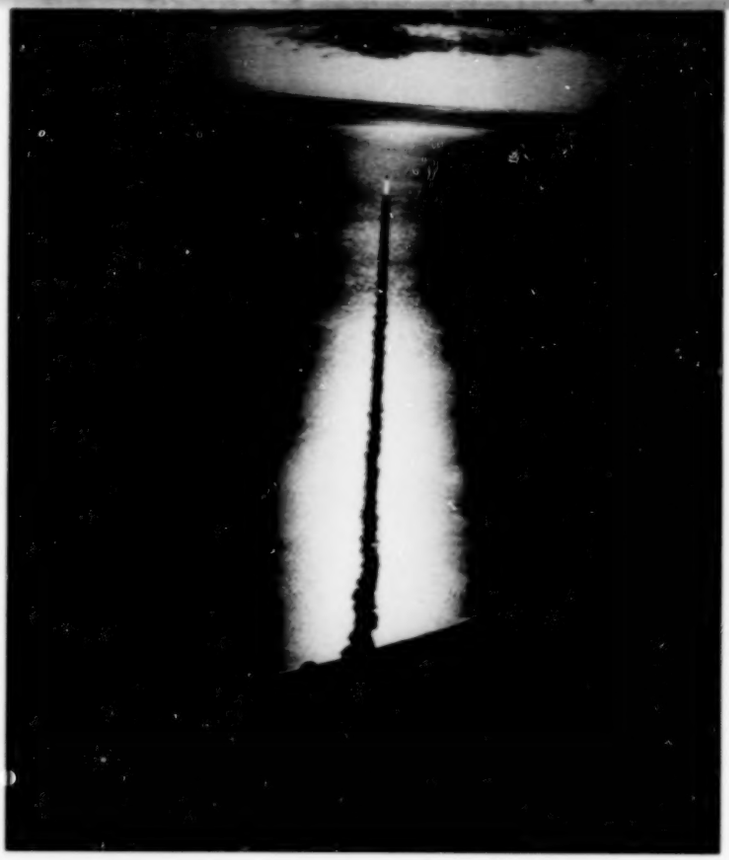
IMAX

Kathy Sullivan

"I had studied this area as a geologist and a reader of the professional literature. It's a huge region, and it's geologically and tectonically complex. Until I flew over it, I still felt sort of bewildered by some of the details I'd been trying to assimilate. Somehow, seeing it all together—in the way that you take something in visually and comprehend it—really was like someone brought the camera into focus, and it went 'Pop!' And I said, 'Yeah, okay'....

We all had flown before, at something like a third to a half of this altitude. We all found [the view] dramatically different. Flying on 41-G had been like flying over this gently curved, endless dish. I don't recall any time on 41-G where I really saw so complete a curvature on the Earth. But on STS-31 there were a couple of instances where it really struck you forcibly that this was a beachball out there."

IMAX camera view of the Himalayas, taken from an altitude of 320 miles. Mission STS-31, 1990.



Steve Hawley

"During ascent, there's not much to see. It's straight up. If you're sitting in front, and you look out the side window during the roll, you'd see the landscape go by, but most of the guys upstairs are pretty busy all the time. If you're sitting downstairs, you're not too busy, but you don't have much of a view.

Normally what happens is you launch to the East. And normally you launch at dawn, so you're flying into the sun. The windows get fogged pretty easily, particularly at SRB separation. Pretty much all you can see coming through the windows is glary sunlight. You don't really get to see the Earth fall away from you....

On my first flight, every time I was tempted to take my eyes off what I was doing to look out the window, I would think about all this training I'd had, what people were counting on me to do, and what if in that instant, something happened and I missed it. So I just didn't let myself be distracted."

First launch of Discovery, photographed by astronaut John Young from the Shuttle Training Aircraft. Mission 41-D, 1984.

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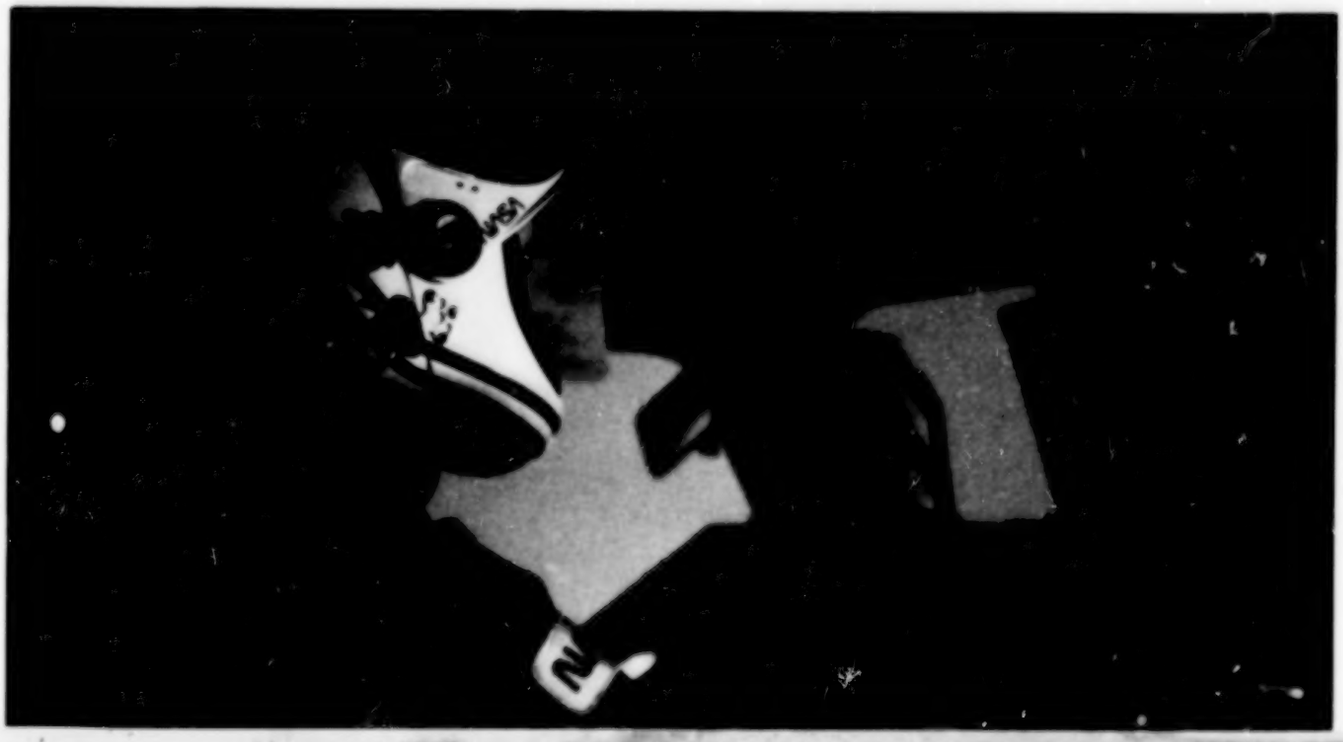
Dave Leestma

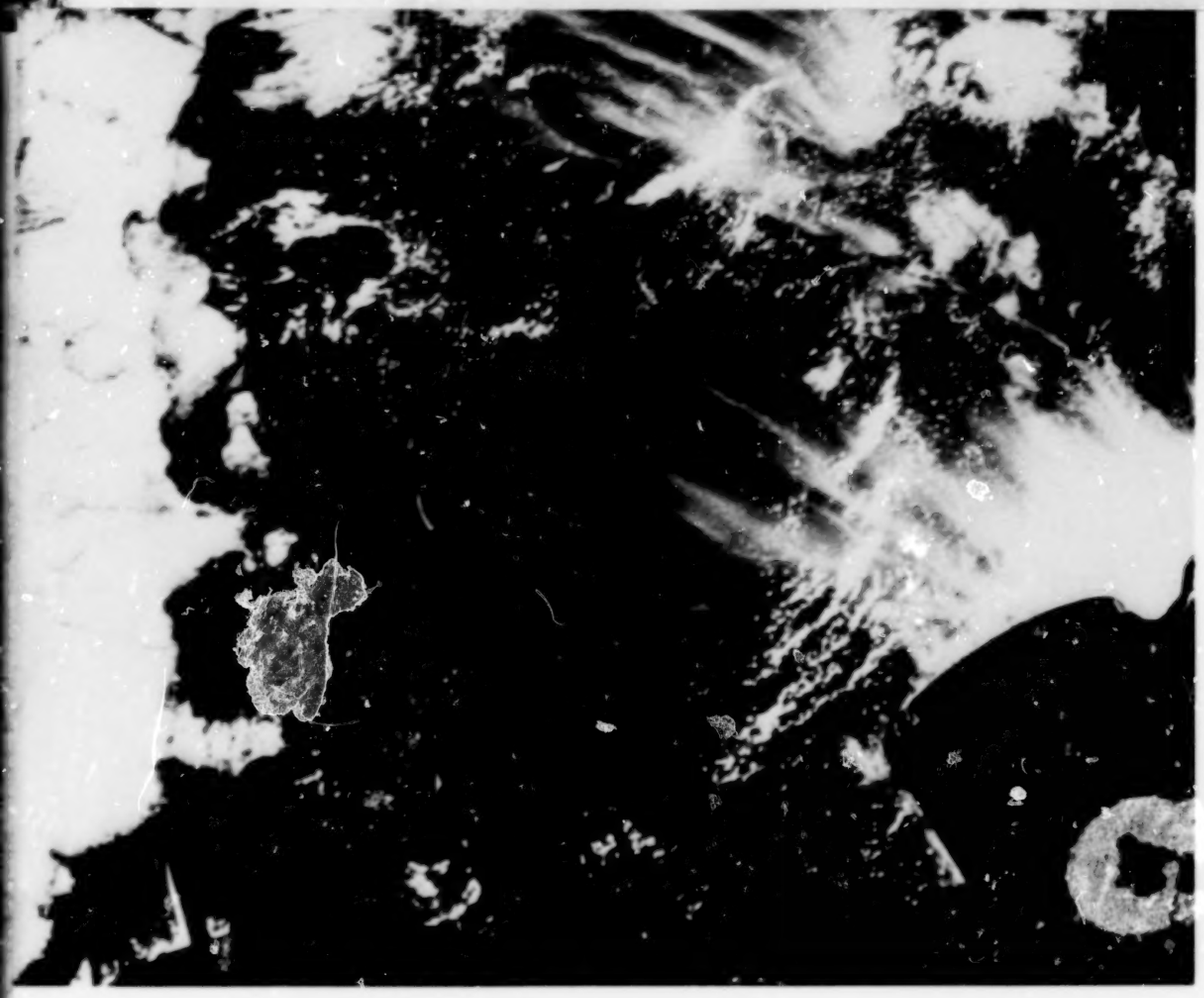
"I was sitting in the seat right behind the pilot. I had a 35-millimeter camera with high-speed film in it—you don't want to flash in anybody's eyes during re-entry, so this is taken with ambient light. I thought it would be neat to show, if you could, the displays on the CRT, and to get Crip *and* the glow out the window. I didn't know it would turn out, but it did....

As the orbiter streaks down back through the atmosphere, it causes a tremendous shock wave that condenses and heats up all the molecules on the other side of the shock behind the orbiter. The glow out the front and side windows starts out pinkish, then gets brighter pink, then white, then down to orange. Once you come into daylight, it disappears. The whole thing usually lasts 10 to 15 minutes....

Overhead, you see an incredible light show. I mean, it's a dancing, weaving, bobbing streak that goes out the back end of the orbiter. We call it 'angry ions,' or 'that thing we carry behind us.' Inside, you're nice and comfortable, but you know it's hot outside just by looking. You're glad you have the tiles on. The still pictures don't really do it justice. You've got to see it in action."

Robert Crippen guides Challenger back through a fiery atmospheric re-entry. Mission 41-G, 1984.





Woody Spring

"We launched this small satellite [a target for testing precision pointing with the orbiter] at the end of our first spacewalk. Our hands were tired [from the construction work]. It weighed 80 pounds [on Earth], and you had to control it pretty well. The objective was just to let it go in orbit with essentially no velocity, or as close as I could. Had I given it a shove, we would have been chasing it. Jerry and I had flipped a coin back in Houston to see who was going to get to launch it, and he lost....

It stayed up in orbit much longer than anybody thought it would—I think it was two and a half years. Over the years, we've let wrenches and gloves and other things go, but I think this was the first thing dropped into orbit on purpose."

Release of the OEX satellite in Earth orbit. Mission 61-B, 1985.

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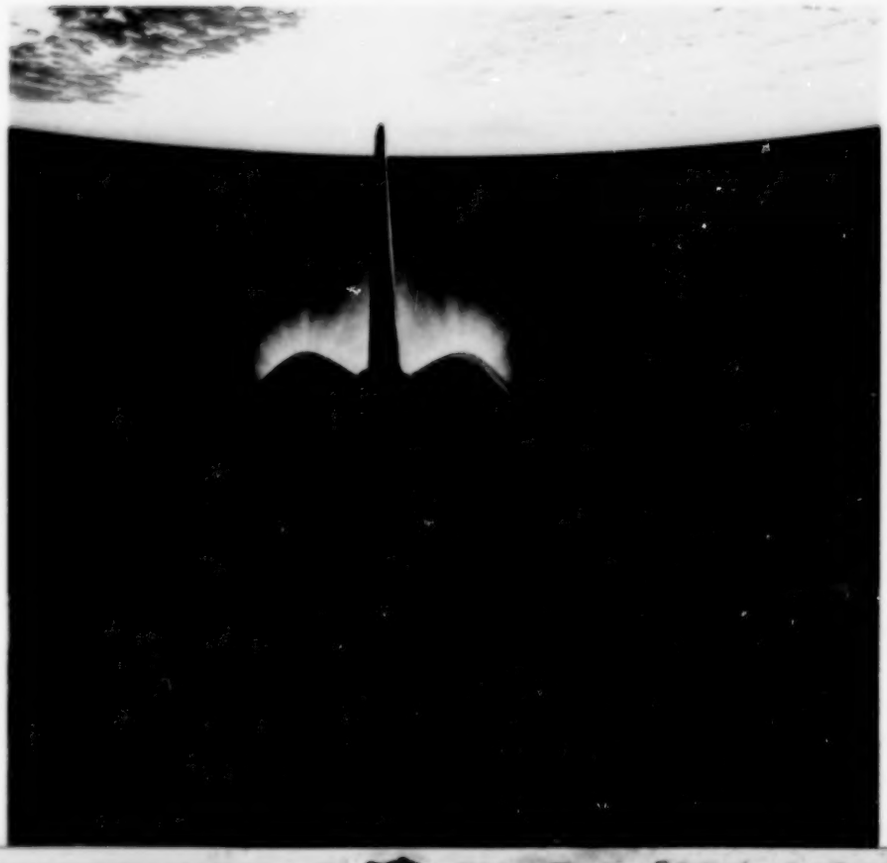

Joe Allen

"When we got into space we had to do the OMS-2 burn to get in a circular orbit, and I was looking out the back window. There was this enormous flash, like a person taking a flash picture, and a sound like a cannon going off. It absolutely scared me to death. I thought the back of the orbiter had blown up. Then, even though the burn continued for as long as a minute, you could see absolutely nothing. No sign of heat, light or anything. I realized what I'd seen was the fuel-rich start of the burn—it's not totally colorless to begin with.

So for every OMS burn we did on that flight, I sat at the window and snapped a picture. When I got back and looked at the photos, lo and behold, I'd gotten it—but only once. All the other pictures were completely blank. From the video, we could tell that the flash lasts only about a tenth of a second. So what I'd done, by total good luck, was to time the 1/250th of a second when the camera shutter opened in that tenth of a second gap. It's only been done once since—by Sally Ride."

Columbia's Orbital Maneuvering System (OMS) engines firing in orbit. Mission STS-5, 1982.

John Fabian

"I think this is a great shot. It shows that you really can get a workout in space—Rick's built up a pretty good sweat....

I exercised on my first flight, but not on my second, because we had seven people in the cabin instead of five. It made it so crowded that you really didn't have a lot of capability to exercise because you were getting in people's way. That treadmill takes up a lot of room. When we landed I could tell the difference between having exercised and not having exercised....

Even with a five-person crew, you have to find time when you won't get in people's way. Most people tend to try to get their exercise midday. Someone will just say 'I'm not busy for the next hour' and go down to get some exercise."

Rick Hauck exercising on the treadmill in Challenger's mid-deck. Mission STS-7, 1983.

Shannon Lucid

"This was actually taken several days after the Galileo deploy. It was kind of a joke. When I flew on 51-G, John Fabian had taught me how to do deploys. He told me you never want to get in front of the TV with your headphones on, because the customer would think you're not giving full attention to the deploy. So I told Ellen we would take this picture with headphones and sunglasses on, and I'd send it to John and tell him he didn't have to worry—I was teaching deploy protocol to the younger generation just as he taught me. Anyway, it turned out to be a pretty good picture. We sort of looked like California Valley Girls."

Mission specialists Ellen Baker (left) and Shannon Lucid onboard Atlantis. Mission STS-34, 1989.

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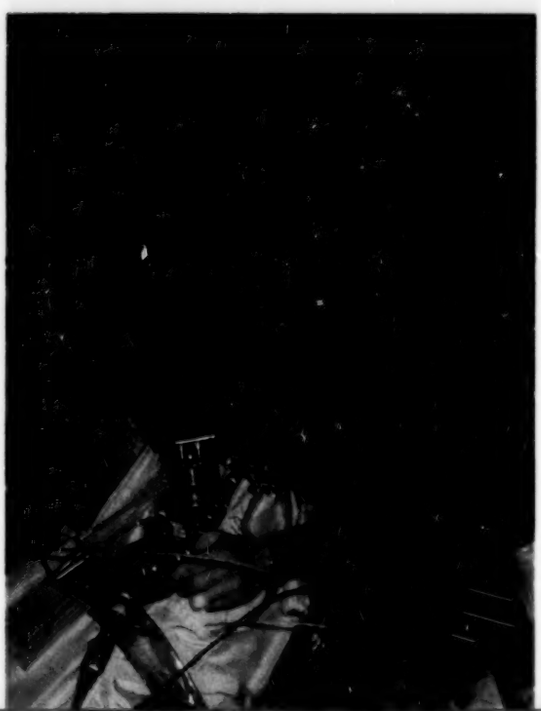
Marsha Ivins

"David hates it when I show this picture, but it's a great picture. The reason for the expression is that he's sealed at the waist, and he's sitting on a bicycle seat—your regular, hard, narrow, pointed bicycle seat—while this neutral pressure device is sucking his body into it for four hours. David's very slim, so sitting on a bicycle seat for four hours in itself would be bad enough. Then you've got all the cables, wires, blood pressure cuffs and electrodes stuck to him. I mean, this is your space hero."

David Low tests a Lower Body Negative Pressure device for countering fluid shift in zero gravity. Mission STS-32, 1990.



The Contributors

THE ASTRONAUTS

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Space Shuttle Mission Chronology

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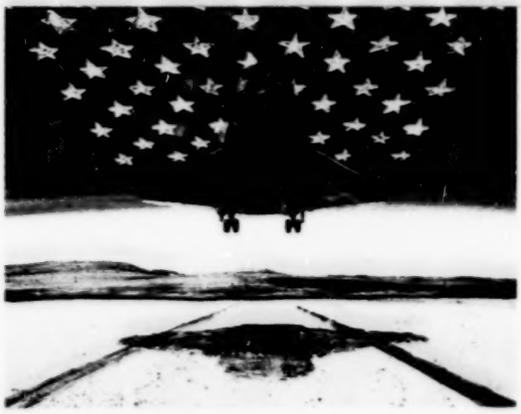
FLIGHT	VEHICLE	CREW	LAUNCH	LANDING	MISSION HIGHLIGHTS
STS-1	Columbia	**Cmdr:** John Young **Pilot:** Robert Crippen	April 12 1981	April 14 1981	First launch of the space shuttle and first landing from space.
STS-2	Columbia	**Cmdr:** Joseph Engle **Pilot:** Richard Truly	November 12 1981	November 14 1981	First test of the shuttle's robot arm. First Earth remote sensing experiments.
STS-3	Columbia	**Cmdr:** Jack Lousma **Pilot:** Charles Fullerton	March 22 1982	March 30 1982	First student experiment. First (and only) landing at White Sands, NM
STS-4	Columbia	**Cmdr:** Thomas Mattingly **Pilot:** Henry Hartsfield	June 24 1982	July 4 1982	Final STS test flight. First commercial experiment.
STS-5	Columbia	**Cmdr:** Vance Brand **Pilot:** Robert Overmyer Mission Specialists: Dr. Joseph Allen Dr. William Lenoir	November 11 1982	November 16 1982	First operational mission. Deployed two satellites: SBS-C and Telesat E. First four-man crew.
STS-6	Challenger	**Cmdr:** Paul Weitz **Pilot:** Karol Bobko Mission Specialists: Donald Petersen Dr. Story Musgrave	April 4 1983	April 9 1983	First Challenger flight. First shuttle "spacewalk." (Petersen & Musgrave) First TRDS Satellite deployed.
STS-7	Challenger	**Cmdr:** Robert Crippen **Pilot:** Frederick Hauck Mission Specialists: John Fabian Dr. Sally Ride Dr. Norman Thagard	June 18 1983	June 24 1983	First American woman in space (Ride). First five-person crew.
STS-8	Challenger	**Cmdr:** Richard Truly **Pilot:** Daniel Brandenstein Mission Specialists: Dale Gardner Guion Bluford, Jr. Dr. William Thornton	August 30 1983	September 5 1983	First night launch & landing. First black American in space (Bluford).
STS-9	Columbia	**Cmdr:** John Young **Pilot:** Brewster Shaw Mission Specialists: Owen Garriott Dr. Robert Parker Dr. Byron Lichtenburg Dr. Ulf Merbold	November 28 1983	December 8 1983	First Spacelab mission.
41-B	Challenger	**Cmdr:** Vance Brand **Pilot:** Robert Gibson Mission Specialists: Bruce McCandless II Robert McNair Robert Stewart	February 3 1984	February 11 1984	First untethered spacewalks. First deployment of the Manned Maneuvering Unit (MMU). First landing at Kennedy Space Center, Florida.



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"Space Shuttle Columbia's First Landing," by Robert McCall, celebrates the approach of the orbiter Columbia at the first shuttle landing in the California Desert on April 14, 1981. NASA Art Program.

FLIGHT	VEHICLE	CREW	LAUNCH	LANDING	MISSION HIGHLIGHTS
41-C	Challenger	**Cmdr:** Robert Crippen **Pilot:** Francis Scobee Mission Specialists: Dr. George Nelson Dr. James Van Hoften Terry Hart	April 6 1984	April 13 1984	First in-orbit capture, repair and redeploy of a satellite, Solar Max.
41-D	Discovery	**Cmdr:** Henry Hartsfield **Pilot:** Michael Coats Mission Specialists: Judith Resnik Richard Mullane Steven Hawley Charles Walker	August 30 1984	September 5 1984	First deployment of three satellites in one mission.
41-G	Challenger	**Cmdr:** Robert Crippen **Pilot:** Jon McBride Mission Specialists: David Leestma Sally Ride Kathryn Sullivan Paul Scully-Power Mark Garneau	October 5 1984	October 13 1984	First American woman to walk in space (Sullivan). First Canadian in space (Garneau). Deployed ERBS satellite.
51-A	Discovery	**Cmdr:** Frederick Hauck **Pilot:** David Walker Mission Specialists: Anna Fisher Dale Gardner Joseph Allen	November 8 1984	November 16 1984	First flight to deploy two satellites and retrieve two others.
51-C	Discovery	**Cmdr:** Thomas Mattingly **Pilot:** Loren Shriver Mission Specialists: James Buchli Ellison Onizuka Gary Payton	January 24 1985	January 27 1985	First Dept. of Defense mission (dedicated).
51-D	Discovery	**Cmdr:** Karol Bobko **Pilot:** Donald Williams Mission Specialists: M. Rhea Seddon S. David Griggs Jeffrey Hoffman Charles Walker Sen. Jake Garn	April 12 1985	April 19 1985	Deployed Leasat and Canadian Anik satellites. First senator/politician to fly in space (Jake Garn).
51-B	Challenger	**Cmdr:** Robert Overmyer **Pilot:** Frederick Gregory Mission Specialists: Don Lind Norman Thagard William Thornton Lodewijk van den Berg Taylor Wang	April 29 1985	May 6 1985	First operational Spacelab flight.

Space Shuttle Mission Chronology

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FLIGHT	VEHICLE	CREW	LAUNCH	LANDING	MISSION HIGHLIGHTS
51-G	Discovery	**Cmdr:** Daniel Brandenstein **Pilot:** John Creighton Mission Specialists: Shannon Lucid Stephen Nagle John Fabian Patrick Baudry Sultan Al-Saud	June 17 1985	June 24 1985	Three communication satellites deployed. First Saudi Arabian in space (Al-Saud).
51-F	Challenger	**Cmdr:** Charles Fullerton **Pilot:** Roy Bridges Mission Specialists: Story Musgrave Anthony England Karl Henize Loren Acton John-David Bartoe	July 29 1985	August 6 1985	First pallet-only Spacelab Mission. First abort to orbit when one engine shut down early.
51-I	Discovery	**Cmdr:** Joe Engle **Pilot:** Richard Covey Mission Specialists: James Van Hoften John Lounge William Fisher	August 27 1985	September 3 1985	Deployed three communications satellites. Fisher & Van Hoften perform longest spacewalk (seven hours, 20 minutes), repairing and redeploying the Leasat 3 satellite.
51-J	Atlantis	**Cmdr:** Karol Bobko **Pilot:** Ronald Grabe Mission Specialists: Robert Stewart David Hilmers William Pailes	October 3 1985	October 7 1985	First Atlantis flight. Second Dept. of Defense Mission.
61-A	Challenger	**Cmdr:** Henry Hartsfield **Pilot:** Steven Nagle Mission Specialists: James Buchli Guion Bluford Bonnie Dunbar Reinhard Furrer Ernst Messerschmid Wubbo Ockels	October 30 1985	November 6 1985	First eight-person crew. German Spacelab mission.
61-B	Atlantis	**Cmdr:** Brewster Shaw **Pilot:** Bryan O'Conner Mission Specialists: Mary Cleave Sherwood Spring Jerry Ross Rodolfo Neri Vela Charles Walker	November 26 1985	December 3 1985	Two EVA's to perform first space construction experiments. First Mexican national in space (Vela).
61-C	Columbia	**Cmdr:** Robert Gipson **Pilot:** Charles Bolden Mission Specialists: Franklin Chang-Diaz Steven Hawley George "Pinky" Nelson Robert Cenker Cong. Bill Nelson	January 12 1985	January 18 1985	First U.S. representative in space (Bill Nelson).

"When Thoughts Turn Inward," by Henry Casselli, depicts a reflective astronaut John Young during suit-up for the first launch of America's Space Shuttle, Columbia. NASA Art Program.

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COLOR PHOTOGRAPH

FLIGHT	VEHICLE	CREW	LAUNCH	LANDING	MISSION HIGHLIGHTS
51-L	Challenger	**Cmdr:** Francis Scobee **Pilot:** Michael Smith Mission Specialists: Judith Resnik Ellison Onizuka Ronald McNair Christa McAuliffe Gregory Jarvis	January 28 1986		First launch failure of the shuttle program, 73 seconds after liftoff; vehicle and crew lost.
STS-26	Discovery	**Cmdr:** Rick Hauck **Pilot:** Richard Covey Mission Specialists: George Nelson Mike Lounge Dave Hilmers	September 29 1988	October 3 1988	First flight after Challenger. TDRS tracking satellite deployed.
STS-27	Atlantis	**Cmdr:** Robert Gibson **Pilot:** Guy Gardner Mission Specialists: Mike Mullane Jerry Ross Bill Shepherd	December 2 1988	December 6 1988	Department of Defense Mission.
STS-29	Discovery	**Cmdr:** Michael Coats **Pilot:** John Blaha Mission Specialists: James Buchli Robert Springer James Bagian	March 13 1989	March 18 1989	Delivered NASA's 4th TDRS tracking satellite to orbit.
STS-30	Atlantis	**Cmdr:** David Walker **Pilot:** Ronald Grabe Mission Specialists: Norman Thagard Mary Cleave Mark Lee	May 4 1989	May 8 1989	Magellan radar mapping probe launched toward Venus.
STS-28	Columbia	**Cmdr:** Brewster Shaw **Pilot:** Richard Richards Mission Specialists: David Leestma James Adamson Mark Brown	August 8 1989	August 13 1989	Department of Defense Mission.
STS-34	Atlantis	**Cmdr:** Donald Williams **Pilot:** Michael McCulley Mission Specialists: Franklin Chang-Diaz Shannon Lucid Ellen Baker	October 18 1989	October 23 1989	Galileo spacecraft launched from shuttle for Jupiter.
STS-33	Discovery	**Cmdr:** Fred Gregory **Pilot:** John Blaha Mission Specialists: Story Musgrave Kathryn Thornton "Sonny" Carter	November 22 1989	November 27 1989	Department of Defense Mission.

Space Shuttle Mission Chronology

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COLOR PHOTOGRAPH

FLIGHT	VEHICLE	CREW	LAUNCH	LANDING	MISSION HIGHLIGHTS
STS-32	Columbia	**Cmdr:** Dan Brandenstein **Pilot:** James Wetherbee Mission Specialists: Bonnie Dunbar Marsha Ivins David Low	January 9 1990	January 20 1990	Long Duration Exposure Facility (LDEF) retrieved from orbit. Longest shuttle flight to date.
STS-36	Atlantis	**Cmdr:** John Creighton **Pilot:** John Casper Mission Specialists: David Hilmers Richard Mullane Pierre Thuot	February 28 1990	March 4 1990	Department of Defense Mission.
STS-31	Discovery	**Cmdr:** Loren Shriver **Pilot:** Charles Bolden Mission Specialists: Bruce McCandless Steven Hawley Kathryn Sullivan	April 24 1990	April 29 1990	Hubble Space Telescope delivered to orbit.
STS-41	Discovery	**Cmdr:** Richard Richards **Pilot:** Robert Cabana Mission Specialists: Bill Shepherd Bruce McInick Thomas Akers	October 6 1990	October 10 1990	Ulysses solar probe launched on interplanetary trajectory to the Sun.
STS-38	Atlantis	**Cmdr:** Richard Covey **Pilot:** Frank Culbertson Mission Specialists: Robert Springer Carl Meade Charles D. (Sam) Gemar	November 15 1990	November 20 1990	Department of Defense Mission.
STS-35	Discovery	**Cmdr:** Vance Brand **Pilot:** Guy Gardner Mission Specialists: Jeffrey Hoffman Mike Lounge Robert Parker Payload Specialists: Ronald Parise Samuel Durrance	December 2 1990	December 10 1990	Astronomy experiments conducted using the Astro-1 ultraviolet observatory.
STS-37	Atlantis	**Cmdr:** Steven Nagel **Pilot:** Kenneth Cameron Mission Specialists: Linda Godwin Jerry Ross Jay Apt	April 5 1991	April 11 1991	Gamma Ray Observatory deployed. First spacewalk since 1985. EVA Development Flight Experiments.

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